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A COMPARATIVE STUDY OF COMMON CORN BELT RATIONS USED IN STEER FEEDING

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I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPERVISION BY ROSCOE RAYMOND SNAPP

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I. INTRODUCTION

History of Cattle Feeding in the Corn Belt.

The history of the feeding of harvested feeds to cattle in the corn belt is a long one and is closely interwoven with the history of crop production in that region. Cattle were brought into the Ohio and Mississippi Valleys by the settlers who came from the seaboard states. Grass was much more pentiful in this fertile region than it had been in the hilly sections to the eastward, and the early farmers allowed their milch cows and oxen to increase without artificial limits, since the question of feed supply now gave them no concern. It was soon found that Indian corn could be grown unusually well in this region and that corn fodder made an excellent feed on which to carry cattle through severe winter weather when the cured grass was heavily covered with snow.

It was in 1804 that Felix Renick, who lived in the Scioto Valley, first conceived the notion of fattening some heavy four-year-old steers on corn fodder during the entire winter period with the idea of driving them to an Atlantic seaboard market the following spring. This plan was successfully carried out and the winter feeding industry of the corn belt was born. Due to the great abundance of native grasses, no attempt was made to fatten cattle before they had attained their maximum growth. Steers were allowed to graze in the summers and were roughed through the winters until the fall of their fourth or fifth year when they were started on a full feed of ear corn, usually in the form of corn fodder. Corn in this form supplied not only the grain component of the ration, but the roughage part as well. Feed was cheap and the cattle were continued on feed for eight or nine

months, being marketed at weights averaging around 1600 - 1800 pounds.

As the country became more thickly settled, large areas of the native grasses were broken up and planted to corn; and corn, in turn was followed after a few years by the tame grass, timothy. Timothy was especially well suited for the simple rotations practiced by the early farmers, since it grew well on poorly drained soil and made hay that could be easily cured and stacked out-of-doors without much loss from bad weather conditions. Consequently, timothy came to form a part of the wintering and fattening rations of cattle, taking the place of the cured native grasses in the case of young cattle and of part of the corn stalks in the case of older cattle that were being prepared for market. Thus it came about that corn, timothy hay, and corn stover, or corn and timothy alone were regarded as the standard feeds for fattening cattle and they were almost universally used throughout the corn belt when the modern agricultural experiment stations made their appearance about 1900.

One of the first projects undertaken by the agricultural experiment stations was the attempt to introduce red clover into the crop rotations followed by the farmers at that period, for the purpose of building up the nitrogen content of the soil. It was recommended that, so far as possible, clover be grown instead of timothy and experimental plots were laid out to demonstrate that increased yeilds of crops would result from land that had previously been seeded down to clover. About the same time the experiment stations began to plan and carry on cattle feeding experiments devised to show the inferiority of the corn, timothy hay, and corn stover ration when compared with corn and clover hay, or with corn and timothy or stover plus some nitrogenous concentrate such as linseed oil meal. With this beginning, the experiment stations have continued their work until now when there is

scarcely a combination of feeds used in fattening cattle that has not been at least roughly tested and compared with other well known rations by one or more stations in the corn belt. Some of the more common rations have been tested again and again by the same station during different years and by different stations during the same year, using cattle of various weights and ages and feeds of various grades and prices. The results of all of these feeding tests have been published from time to time in the bulletins and circulars issued by the different stations. It is from these reports that the material for this paper has been collected.

Purpose and Scope of Study

Even a casual reader of the reports of feeding tests published by the experiment stations must be impressed by the many apparent disagreements in the results obtained from the use of the same ration by one or more stations during different years. For a sound explanation of such differences one does not have far to seek. In feeding animals one is dealing with living things and the products of living things and it is the nature of living things to be unlike, to vary, as we say. No matter how carefully animals are selected, no two are exactly alike. Especially are they unlike in their capacity for making growth. Moreover, feeds differ in their palatability, moisture content, and chemical composition; while climatic conditions and the physical surroundings of the cattle differ from year to year and between one station and another. In spite of the fact that experiment stations take every precaution to maintain normal conditions throughout their feeding tests, there often arise unforeseen and unpreventable conditions that materially affect the results obtained. The following extracts from cattle feeding bulletins show how serious such conditions sometimes are.

"The ear corn used.......contained a very high percent of moisture and was at times slightly frozen. The shelled corn.......was comparatively free from rotten grains and dirt and with the exception of one week, free from mould. The shredded stover was very poor, a large part of it having been struck by a hailstorm late in the season, and all of it damaged very materially by being stored in the barn in bad condition. The corn silage was of fair quality, showing some mouldy spots that could not be separated without excessive waste. It carried a relatively high percent of moisture."

Pennsylvania Bulletin No. 102

"The prairie hay and alfalfa were usually of good quality. The corn usually graded No. 3, but some of it graded lower. As a whole, it was of a rather poor quality. .... The silage fed during 1911-12 was made from corn that was injured by dry weather. If it had been harvested it would have yielded from 3 to 5 bushels per acre. The silage fed during the following winter was made from corn that would have yielded 25 to 30 bushels per acre."

Nebraska Bulletin No. 143

"The mild winter of 1906-07 and 1907-08, together with a large amount of rainfall, kept the lots muddy throughout a greater part of the time covered by the experiments. This undoubtedly had some effect upon the cost of gains of the different lots."

Indiana Bulletin No. 129

"During the first trial, however, one steer in Lot 1, receiving ear corn, for some unknown reason failed to thrive during the last 40 days of the test. He ate very little during this time and lost 120 pounds. In the second trial one steer in Lot 4, receiving corn and cob meal, had an attack of enteritis and did not thrive during the last 60 days. No changes in the records have been made, however, on account of the lack of thrift in these

two steers."

Missouri Bulletin No. 149

But if such variable conditions prevail at experiment stations where every possible care is taken to obtain uniformity of animals, standard grades of feeds, and normal surroundings, how much more do conditions differ between any one station and the hundreds of farms over the corn belt where little or no attempt is made to standardize conditions from year to year! On some farms, silage is put up in the dough stage; on others, when the corn is quite ripe. One man buys choice feeders; another common or medium grade. One year the corn is cribbed sound and ripe; the next it is light and chaffy or possibly soft and sappy. How, with all of these variations that cannot be avoided under actual farm conditions, can the results of the experiment stations be utilized by the farmers? And since the results of the different stations do not always agree, which result should a particular farmer use for a given year?

It is stated above that all living things vary. For this reason, any study of living things is nearly always made from groups and an average result obtained for the group. No experiment station feeds one steer during a feeding trial, but a drove, consisting of from 5 to 15 animals, and the average result of all of them is obtained and assigned to the ration in question. In this way, the poor steers are balanced by those that do unusually well; so that the average for the lot is really a very good indication of the results that may be expected from the ration with steers of ordinary or average capacity. Now, if in the same way we should average all of the results obtained by all stations for a given ration, we will obtain a result of much more value to the practical feeders than the result obtained by a single station with a single lot of cattle. In this way the choice

steers used by one station will be balanced by the medium steers used by another; the wet silage made at one place counteracted by the dry silage made elsewhere; and the effects of cold, severe weather prevalent one year will be largely neutralized by mild, temperate climate that continued throughout another test. The farmer planning his cattle operations cannot foresee the wet weather; many times he brings home cattle very different in flesh and breeding from those he expected to feed when he laid his plans in mid-summer; and not infrequently he buys his cattle before he knows the exact amount or the quality of the feeds he will harvest. For these reasons the farmer must plan for average conditions, varying his plans from year to year as circumstances require. Being unable to forecast the future with any degree of accuracy, he wants information about the thing he is most likely to encounter, viz., average conditions. Such information can be best furnished in the form of average results, obtained by combining all of the results obtained under the many different conditions that have prevailed during the testing of the ration in question by the different experiment stations. This has been done in the pages that follow, and the averages for the principal rations used by corn belt cattle feeders are given and briefly compared in the body of this paper. In averaging such results care has been taken to see that approximately the same general conditions prevailed in each of the tests that are considered in obtaining an average. Unless this is done, the figures obtained would have little value, even as a guide, to be used under normal circumstances. Accordingly, the following requirements were observed in selecting the experimental results to be used in compiling average results for the rations concerned.

1. Age of cattle: Long yearlings and two-year-olds.
2. Initial weight of cattle: 800 - 1150 pounds.

3. Length of feeding period: 100 - 180 days.

4. Daily feed of corn: Over 10 pounds (Shelled basis)

5. Method of feeding: Full fed throughout period.

Previous investigations[1] show that there is but little difference between the behavior of cattle varying from 800 to 1100 pounds in weight. Cattle under 800 pounds and of the age selected are usually very thin, stunted, and of inferior breeding; while those exceeding 1150 pounds in weight are usually around three years of age or are carrying too much flesh to be regarded as typical feeders. Most cattle are purchased with the idea of feeding them at least 100 days. Whether they are actually fed longer depends largely upon the probable condition of the fat cattle market in the near future, particularly upon whether or not a decided premium will likely be paid for well finished beeves. It is realized that 10 pounds of corn per head per day is a rather low limit for full fed cattle of this age and weight. However, only an insignificant number of lots received so small an amount. Most of the silage fed cattle consumed from 13 to 15 pounds of corn per head daily, while those not getting silage ate from three to four pounds more. All lots of cattle were full fed throughout the period. That is, they were gotten on full feed as quickly as possible, usually by the end of the first month of the test.

An effort has been made to compare all rations suitable to corn belt conditions. Accordingly, a study has been made of all available beef cattle bulletins, circulars, and reports issued by the experiment stations of the corn belt states, - viz., Ohio, Indiana, Pennsylvania, Illinois, Wisconsin, Iowa, Nebraska, Kansas, and Missouri. Unusual rations, or feeding trials conducted

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[1] Renumerative Prices for Beef Cattle Fattened in the Corn Belt: Wilcox, 1919.

under unusual conditions were passed by without tabulation, but all results obtained from trials carried on under conditions likely to be encountered in practical feeding operations were carefully analyzed and the following facts ascertained:[1]

1. Title and number of publication reporting trial.
2. Year conducted.
3. Length of feeding period.
4. Number of cattle fed.
5. Initial weight of cattle.
6. Total gain.
7. Final weight.
8. Average daily gain.
9. Feed per pound gain.
10. Daily feed of corn (shelled basis)
11. Method of preparation of corn.
12. Hogs per steer in feed lot.
13. Pork produced per steer from droppings.
14. Pork produced per bushel of corn fed cattle.

A few stations did not regularly report the last three items, but all other items were either obtained directly from the bulletins, or were calculated from the data actually presented. Many stations make a practice of reporting the "average daily feed" instead of "feed per pound gain". In such cases the latter was calculated by dividing the total consumption of

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[1] Several trials involving typical corn belt rations had to be thrown out because of the absence of sufficient data on the amounts of the different feeding stuffs fed.

feed by the total gains made. Care was taken to reduce all ear corn to a shelled basis. In a few cases where both shelled and ear corn were fed, the data given was insufficient to permit the calculation of the actual amount of each used during the feeding period. Such trials were rejected altogether.

A considerable number of rations were tabulated that will not appear at all in the discussion given in the body of the paper, for the simple reason that the number of tests in which these rations were used under the limits adopted was insufficient to permit the calculation of a dependable "average" for such rations. Unfortunately a few of the rations that are thus omitted are of considerable importance; e.g., corn, linseed oil meal, and silage; and corn, linseed oil meal, clover, and silage. It happened that but one test of each of these rations was discovered where all the conditions set forth above were met. In general, however, such omissions are of minor importance and, if included, would serve merely to increase the length of the discussion. The following table summarizes the extent of the material that was tabulated and the per cent that actually appears in the comparisons hereinafter made:

Table A. Data Tabulated and Studied.

	Full Fed Cattle			Limited Grain Ration	Total
	Number Tabulated	No. used in comparison	Per cent Used		
Different Experiment Stations	8	8	100	7	8
Number of seasons covered	23	22	95	11	23
Number of lots of cattle	334	205	61	85	419
Total number of cattle	3261	1855	57	836	4097
Number of different rations	52	23	44	23	75

The rapid growth in experimental feeding of beef cattle on the part of corn belt stations is shown by the following table, in which all of the lots tabluated are grouped according to the five year period in which they were fed. Such a grouping shows clearly the important place held by limited grain rations in investigations carried on in recent years.

Table B. Growth of Experimental Beef Cattle Feeding

Period	Lots Full Fed	Lots on Limited Grain Ration	Total
Before 1900-01	18	--	18
1900-01 to 1904-05	36	--	36
1905-06 to 1909-10	68	2	70
1910-11 to 1914-15	110	19	129
1915-16 to 1919-20	102	64	166
Total	334	85	419

Method of Comparing Rations.

No attempt has been made to compare rations that are quite different from each other, A study of the following pages will show that rations have been grouped together, and that those within a certain group differ from one another usually in but a single respect, e.g., the nature of the protein constituent, or the kind of dry roughage fed. Only by limiting the differences in this way can the differences in results obtained be definitely accounted for and explained. The rations forming each of these groups have been compared on the following points:

1. Average daily gain.
2. Feed per pound gain.
3. Digestible nutrients per pound gain.

4. Pork produced per bushel of corn fed cattle.

5. Replacement value of feeds.

All of these items except number 3 are of vital interest to the practical cattle feeder. Number 3 is included because it occasionally helps to explain certain results that are obtained.

With any given ration, the daily gains obtained vary somewhat between different lots. However, this item varies to a greater extent with some rations than with others. For this reaons "the probable error of a single lot" has been calculated and is shown for all rations used by at least 7 lots of cattle. It was felt that the probable error would have little significance where less than 7 results were averaged. The smaller the probable error the more importance can be attached to the figure representing the average daily gain. In comparing one ration with another, it will be noticed that in few cases is the difference in daily gains greater than the probable error of either of them; that is to say, in few cases is the difference in daily gain of sufficient size to let this figure be of major importance in determining the comparative value of two rations. There are, however, some notable exceptions to this statement which must not be overlooked. It may be said that the daily gains are an index of finish, and as such are important, even though the differences between them be small. While admitting that this is true, it is argued that the lack of certainty as to whether the market 100 or 150 days hence will pay a substantial premium for a little extra finish largely discounts this advantage under present day market conditions, It may be stated that large daily gains mean a large necessary margin since every pound of gain is put on at a cost greater than its selling price. In all probability it will be found that the increased selling price per cwt. due to higher finish will be no larger than necessary to make up the greater loss resulting from greater total

gains, provided the cost of gains is the same in both cases. Consequently, it appears that the most important difference between rations is the difference in cost of gains or feed per pound gain; and this is the point that has been emphasized in the discussion of the following tables, under both the headings, "Feed per pound gain" and "The replacement value of feeds". To still further justify the importance attached throughout this paper to the item, "feed per pound gain", the following discussion is given of the relation existing between the factors that have considerable weight in determining the profit to be realized from any feeding operation.

Relation Between Rate of Gain, Cost of Gain, Selling Price, and Profit.

The purpose of all cattle feeding operations is to secure a profit. As a rule farmers are interested in bulletins reporting experiments only in so far as they can learn what method of feeding gives the largest financial return. But the matter of profits necessarily involves the question of prices, prices of feeder cattle, prices of each of the feeding stuffs used, and the prices at which the fat cattle are sold. These prices are constantly changing, both relatively and absolutely, so that no set of prices that may be used in preparing a bulletin is likely to be applicable to the conditions prevailing at a later date when the bulletin is read and studied by the farmers. Any comparisons of feeds that is to be of value for any length of time must be made on some basis other than price. But if it is to be of real use to the practical feeder, it must be of such a nature that it can be quickly and easily converted into terms of dollars and cents, and so made understandable to him.

Probably the best stable comparison that can be made between two or more rations is the amounts of feed necessary to produce a pound of gain in

weight. These figures are not only unaffected by economic conditions, but they can be easily and quickly changed into up-to-date "financial statements" by simply calculating the monetary value of the feeds eaten per pound gain on the basis of current prices. Thus that ration is best under given conditions that permits an increase of one pound in weight with the least expensive feeds. It is this comparison that enables the feeder to determine which ration will result in the least outlay for feed; and since feed costs make up from 75 to 80 per cent[1] of the total expense of fattening, it is this comparison that permits the operator to select his raw materials with a view of keeping down his "cost of production".

But profits are not determined wholly by low cost of production. The article produced must satisfy the demands of the market to the extent that it can be sold at a fair price. In other words, profits from steer feeding depend upon a high selling price per pound as well as upon a low cost per pound gain. Unfortunately no good stable index for the selling price is available. In a measure it corresponds with the finish of the animal - the higher the finish, the higher the selling price as a general rule. The degree of finish, of course, depends directly upon the daily gains and the length of the feeding period, two figures that have no tendency to be influenced by economic condition. Since in the comparisonsmade in this paper the feeding periods are approximately the same, we may say that the degree of finish produced by a given ration is shown directly by the size of the daily gains made. But while better finish, that is, greater total amount of gain, usually results in a larger selling price per pound, it also results in a larger total feed cost; and since gains are always sold at a loss, the larger the gains made, the less the profit, other things, of course, being the same. Under actual market conditions the premium

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[1] Renumerative Prices for Beef Cattle Fattened in the Corn Belt. Wilcox, 1919.

realized by cattle of high finish is usually, but by no means always, sufficient to reimburse the feeder for the high cost of feed incident to producing that finish. However, these two factors tend to neutralize each other in determining profit - the increase in income resulting from a higher selling price being largely eaten up by a corresponding increase in feed costs. That farmers in general realize the truth of this statement is shown by their tendency to market the great bulk of their cattle in simply good killing condition.

But occasionally well finished cattle sell at a substantial premium. Also rapid gains are not necessarily more expensive than gains made somewhat more slowly. What factore are, as a rule, of more importance in determining the amount of profit realized from a cattle feeding venture? In an attempt to throw some light on the answer to this question, a study was made of the first 10 years experimental work done at the Indiana Station. The findings of this study are given below:

Table C. Relation Between Factors Affecting Profit.

1.	Largest total gains resulted in high selling price	7 years out of 10*
2.	Largest total gains [with uniform (average) cost of gains per pound] resulted in largest profit	4 years out of 10
3.	High selling price (with uniform cost of gain) resulted in largest profit	6 years out of 10
4.	Largest total gains resulted in lowest actual cost of gain	7 years out of 10
5.	Lowest cost of gains resulted in largest actual profit	8 years out of 10

* In 3 of these years the selling price was equalled by lots with smaller total gains.

From this table it appears that a closer relation exists between cost of gain and profit than between any other two factors; also that the size of the total gains, which is the same as the size of the daily gains, is a very good index of the probable cost of the gains per hundred weight. Selling price alone has little influence on profit. Fortunately for the cattleman, rapid gains, cost per pound gain, and selling price are usually all working towards increasing the profit, but the greatest and most constant of these three is the cost per pound gain. It is for this reason that it receives most attention in the discussion of the tables that follow.

It is freely admitted that there was for a given ration often considerable variation in the amounts of the different feeds necessary to produce a pound of gain. Most of this was due to variations between different stations, and at the same station during different years, in the proportion of the different feeds used in making up the ration. At first glance it may seem that such differences would seriously impair the value of any "average" that might be calculated from such results; but a reference to the object of the investigation will recall that, since such variation must exist under practical conditions from year to year, due to variations in the production and supply of certain feeding stuffs, their presence in the tests tabulated will tend to make the "average feed per pound gain" of more practical value to commercial cattle feeders than would be the case if the same proportions of feed had been maintained throughout all of the tests. The average results of several farmers or of one farmer over a period of years will closely approach the average of these many experiment stations; while a particular result of a given farmer will undoubtedly be much farther from one particular result of any station that might be empirically selected as a "model".

Digestible Nutrients.

Figures showing the amounts of digestible nutrients, as well as the net energy per pound of gain, as given by Henry and Morrison's "Feeds and Feeding" were included in the tables with the hope that they might give a cue to a ready explanation of the differences observed in the effect of the rations on the cattle. In few cases, however, have they been of any great service in this respect.

Pork Production After Cattle.

The amount of pork produced by hogs following the cattle has been stated in terms of pounds of pork per bushel of corn fed the cattle. In case any feed was supplied the hogs beyond that obtained after the cattle, the "pork equivalent" of such feed was deducted from the total amount of pork produced. In calculating this pork equivalent, it was considered that five pounds of corn alone would produce one pound of pork, while but four and a half pounds of a balanced ration were necessary. In all of the following tables the figures for pork represent only those lots in which the cattle were fed shelled corn. A special table in the appendix gives the amount of pork produced for each common method of preparing corn.

II. COMPARISON OF RATIONS

i. CORN AND HAY

As stated above corn and timothy hay formed the first ration to be used extensively in the winter feeding of cattle. Consequently early cattle feeding experiments almost invariably provided for a "check lot" that received this ration while other lots were fed rations that were not so commonly used by practical cattlemen. Corn being plentiful and cheap, no attempt was made to replace any considerable quantity of that feed. Attention was rather given to the roughage part of the ration, and in the East corn and timothy were compared with corn and clover, while in the West, corn and prairie hay were compared with corn and alfalfa. Later when the possibility of growing alfalfa in almost all parts of the corn belt was realized, corn and clover were compared with corn and alfalfa. The following table gives the average results of all tests involving these rations that were carried on under the conditions adopted in defining the limits of this paper.

Table I. Comparison of Different Kinds of Hay When Fed With Corn

	Corn and Timothy hay	Corn and Prairie hay	Corn and Clover hay	Corn and Alfalfa hay
Number of stations	2	1	2	3
Number of seasons	5	3	6	10
Number of lots fed	12	3	6	20
Number of cattle	56	30	68	226
Average length of period	110 days	136 days	167 days	138 days
Average daily gain	1.85±.17	1.51	2.08±.14	2.40±.20
Feed per pound gain				
Corn	11.09	11.71	9.07	6.90
Hay	4.39	5.21	4.56	4.73
Average corn per day	21.7	17.1	18.00	16.60
Digestible crude protein per pound gain	.974	1.09	1.03	1.02
Total digestible nutrients per pound gain	11.67	12.56	10.12	8.37
Digestible true protein per pound gain	.846		.863	.796
Total net energy per pound gain	11.32		9.64	8.75
Pork per bushel corn fed steers	1.25	1.37	1.43	.85

Daily Gains.

Much difference exists between the daily gains resulting from the use of the above rations. If the gains made by cattle receiving alfalfa be taken as 100 then the other gains would be represented as follows:

Alfalfa 100; clover 87; timothy 77; prairie 63. Or following out the suggestion presented in the introduction, the time required for cattle to increase 300 pounds in weight on these rations would be, alfalfa 125 days, clover 144 days, timothy 162 days, and prairie 200 days.

At first glance one might be inclined to question the reliability of the prairie hay figures since the daily gains are so much lower than those for timothy. While it is admitted that the number of trials studied in obtaining the results for prairie hay was noticeably fewer than was the case with the other rations, still considerable importance should be attached to them for the following reason. In only one of the twelve lots fed timothy was the daily gain as low as the average for the prairie hay fed cattle; and in only one of the prairie hay lots was the gain as high as the average of the timothy lots.

Feed per Pound Gain:

The efficiency of these rations for producing gains is in the same order as the size of the daily gains made. In as much as the amount of roughage per pound gain is approximately the same in the different groups, the efficiency of the rations is fairly well represented by the amount of corn required per pound of gain, or in round numbers:

Alfalfa 7, clover 9, timothy 11, prairie 12.

Nutrients per Pound Gain.

There is little difference in the amounts of digestible crude protein eaten per pound gain. The difference in this respect between clover and

alfalfa is less than one per cent; while that between timothy and prairie is but slightly over ten per cent. In the case of total digestible nutrients it is seen that approximately the same ratios exist between these figures as between the amounts of corn per pound gain; viz:

Alfalfa 8.4; clover 10; timothy 11.7; prairie 12.6.

The same ratio holds true for the total net energies; viz:

Alfalfa 8.7; clover 9.6; timothy 11.3; prairie -.

Pork Produced.

With the exception of the lot getting clover hay the amount of pork produced is almost exactly directly proportional to the corn required per pound gain; viz:

Alfalfa .85; clover 1.43; timothy 1.25; prairie hay 1.37.

Expressing these in index numbers comparable in size with those used above we have:

Alfalfa 7; clover 12; timothy 10.4; prairie 11.4.

This is exactly what we should expect, since this pork is the result of all grain not utilized by the cattle. An inspection of the separate results of the clover hay trials shows that the pork produced from one lot of cattle was abnormally high. Rejecting this one test, the average pork per bushel of corn fed the clover hay cattle is 1.28 pounds. This would permit the changing of the above ratio figure for clover from 12 to 10.7. Even this is somewhat high compared with the corresponding index figure for corn per pound gain.

Replacement of Feeds:

Table Ia

1 ton	Timothy and corn	Prairie hay and corn	Clover and corn	Alfalfa and corn
Timothy		1.2 T + 5 bu.	1.0 T - 15.6 bu.	1.08 T - 34 bu.
Prairie	.85 T - 4.3 bu.		.875 T - 18 bu.	.9 T - 33 bu.
Clover	.94 T + 16 bu.	1.1 T + 21 bu.		1.04 T - 17 bu.
Alfalfa	.93 T + 32 bu.	1.1 T + 36.5 bu.	.96T + 16.4 bu.	

Explanation of Table Ia.

This table is made from the amount of feed required per pound gain with different kinds of hay. From this table it is seen that one ton of timothy when fed with corn will produce as much gain as 1.2 tons of prairie hay along with 5 bushels more corn than would be required with the timothy. Accordingly a feeder would prefer timothy to prairie hay unless the price of timothy exceeded the price of 1.2 tons of prairie hay plus the value of 5 bushels of corn. Similarly clover will be preferred to alfalfa only when the price of clover per ton is less than the cost of 1.04 tons of alfalfa minus the value of 17 bushels of corn. By means of such a table it is easy to calculate the cheapest source of roughage where corn and hay forms the entire ration.

It is interesting to see how closely comparisons derived from this table in different ways check with one another. In the first vertical column we get the following equations:

(1) 1 ton clover = .94 tons timothy + 16 bushels corn

$\therefore$ 1 ton clover - 16 bushels corn = .94 ton timothy

and

(2) 1 ton alfalfa = .93 ton timothy + 32 bushels corn

∴ 1 ton alfalfa - 32 bushels corn = .93 ton timothy

Consequently

1 ton clover - 16 bushels corn = 1 ton alfalfa - 32 bushels corn

∴ 1 ton clover + 16 bushels corn = 1 ton alfalfa

Similarly using the results in the second column

1 ton clover + 15.5 bushels corn = 1 ton alfalfa

Also in the extreme right column we have

1 ton clover + 17 bushels corn = 1.04 ton alfalfa

Such close agreement indicates that no important errors have been made in the many subtractions and divisions performed in constructing Table Ia.

Table Ib
(Constructed from Table Ia)

	Timothy $20 Corn $.50	Prairie hay $16 Corn $.50	Clover $16 Corn $.50	Alfalfa $20 Corn $.50
Timothy		$21.70	$8.20	$4.60
Prairie	$14.85		$5.00	$1.50
Clover	$27.80	$28.10		$12.30
Alfalfa	$34.60	$35.85	$23.56	

The figures given in Table Ib indicate that something is seriously wrong, for in only a few instances do the computed prices of the roughages based upon the ordinary market value of the feeds they displace correspond at all closely with the market value of the roughages themselves. This points to the fact that the market price of a feeding stuff used need not be even an approximate index of its feeding value. Especially is this true of feeds like timothy and prairie hay that are used extensively for horses because of their freedom from dust and molds rather than for their value as a source of nutrients.

A study of the table will disclose that the prices taken for timothy and prairie hay express approximately the comparative value of these two feeds since their substitutive values closely approach their market values. Likewise, the prices taken for clover and alfalfa are in approximately the same ratio as the nutritive value of these feeds since the market price of either is not far from the value of the feeds displaced when it is substituted for the other. But there is absolutely no agreement between the market prices of the carbonaceous and nitrogenous roughages and their substitutive values as shown in the above table. Such a condition points to the fact that based upon their actual feeding value, either timothy and prairie hay are priced entirely too high, or clover and alfalfa hay are quoted entirely too low.

Such a wide disagreement between the market value and feeding value of these feeds raises the question as to the possibility of discovering a money price that would be a true index of their real feeding value. The results of an attempt to find such a price is given below:

Let t = 1 ton of timothy
p = 1 ton of prairie hay
c = 1 ton of clover
a = 1 ton of alfalfa
n = 1 bushel of corn

Then from Table Ia

$$.85\ t - 4.3\ n = .875\ c - 18\ n \qquad (1)$$

whence $$.875\ c - .85\ t = 13.7\ n \qquad (2)$$

But $$c = .94\ t + 16\ n \qquad (3)$$

Substituting 3 in 2
and simplifying $$.3n = .03\ t \qquad (4)$$

$$t = 10\ n \qquad (5)$$

Hence from table $$p = .85\ t - 4.3\ n = 4.2\ n \qquad (6)$$

$$c = .94\ t + 16\ n = 25.4\ n \qquad (7)$$

$$a = .93\ t + 32\ n = 41.3\ n \qquad (8)$$

Thus we have all roughages expressed in terms of bushels of corn, and these expressions are based solely upon their comparative feeding value. Taking the market price of corn at $.50 a bushel, we have the following values for the hays concerned.

Timothy	$5.00 per ton
Prairie	2.10 " "
Clover	12.70 " "
Alfalfa	20.65 " "

If these values are used in solving the various equations of Table Ia, we should get a much closer agreement of values than we have in Table Ib, where ordinary market prices of these feeds are used.

Table Ic

1 ton	Timothy $5 Corn $.50	Prairie Hay $2.10 Corn $.50	Clover $12.70 Corn $.50	Alfalfa $20.65 Corn $.50
Timothy		$5.02	$4.90	$5.30
Prairie hay	$2.10		$2.11	$2.08
Clover	$12.70	$12.81		$ 12.97
Alfalfa	$20.65	$20.56	$20.39	

The close agreement between these figures is little short of remarkable. They emphasize the fact that the feeding values of these roughages as given above in terms of bushels of corn are not far from correct. By means of these simple formulae the practical feeder, who is contemplating feeding corn and some sort of hay, will select that roughage, the feeding value of which based on the price of corn is equal to or above its market price.

II. CORN, NITROGENOUS CONCENTRATE, AND LEGUME HAY

As stated above it was early shown that a nitrogenous roughage was greatly superior to a carbonaceous roughage; also that the addition of a nitrogenous concentrate to a ration not containing a legume resulted in great improvement in every respect. The next natural step for experiment stations to take was to see whether or not the use of a nitrogenous concentrate with a nitrogenous roughage would produce better results than the use of either of them alone. Accordingly we find that many investigations conducted during the period 1904-1908 were devoted to finding a correct answer to this question. A study of the following table will show that one station (Indiana) has used the ration, corn, cottonseed meal, and clover during ten different feeding seasons, while three different stations have tested corn and alfalfa for the same length of time. Averages of such results should be good indices of the relative value of these rations over a long series of years.

Table II. Comparison of Corn and Legume Hay With and Without Nitrogenous Supplements

	Corn and Clover Hay	Corn C.S.M. Clover Hay	Corn L.S.O.M. Clover Hay	Corn Alfalfa	Corn C.S.M. Alfalfa	Corn L.S.O.M. Alfalfa
No. of stations	2	1	2	3	3	3
No. of seasons	6	10	2	10	6	3
No. of lots	6	11	3	20	10	3
No. of cattle	68	115	39	226	97	27
Ave. time fed	167	160	103	138	139	128
Ave. daily gain	2.08±.14	2.40±.11	3.12	2.40±.20	2.53±.23	3.10
Feed per lb. gain						
Corn	9.07	7.25	6.31	6.90	6.46	5.35
C.S.M.		1.21			.89	
L.S.O.M.			.98			.75
Hay	4.56	4.61	3.82	4.73	4.51	3.56
Lbs. Dig. crude protein per lb. gain	1.03	1.29	1.06	1.02	1.26	1.00
Total dig. nutrient per lb. gain	10.12	9.47	8.12	8.37	8.53	7.00
Lbs. dig. true protein per lb. gain	.863	1.17	.91	.80	1.06	.82
Total net energy per lb. gain	9.64	9.06	7.70	8.75	8.03	6.50
Ave. corn per day	18.00	17.5	19.7	16.60	16.3	16.5
Pork per bushel corn fed cattle	1.43	1.44	1.67	.85	1.56	.90

Daily Gains.

From the standpoint of daily gains clover ranks considerable below alfalfa when fed alone with corn. When supplemented with cottonseed meal the gains realized with clover are approximately equal to those made by alfalfa. When linseed oil meal is used as a supplement, clover and alfalfa seem equally efficient from the standpoint of daily gains. That greater gains will result from the use of linseed oil meal than from the use of cottonseed meal is shown in a striking manner by the table. In the case of alfalfa hay not a single lot getting cottonseed meal made daily gains as high as the average of the lots getting linseed oil meal, while no oil meal fed lot made gains as low as the average for the lots getting cottonseed. With clover hay the difference was still greater. The largest daily gain of the 11 lots getting cottonseed meal was considerably lower than the smallest gains of the three lots getting linseed meal. Index numbers for daily gains are as follows:

Clover 87; Cottonseed meal and clover 100; Linseed oil meal and clover 130.

Alfalfa 100; Cottonseed meal and alfalfa 105; Linseed oil meal and alfalfa 130.

Time required to realize 300 pounds increase in weight:

Clover 144 days; cottonseed meal and clover 125 days; linseed oil meal and clover 96 days.

Alfalfa 125 days; cottonseed meal and alfalfa 119 days; linseed oil meal and alfalfa 97 days.

Feed per Pound Gain.

Practically equal amounts of roughage were required per pound of gain in all lots except the lots receiving linseed oil meal. Apparently it can be said that the use of linseed oil meal will increase the efficiency of the roughage part of the ration.

The superiority of linseed oil meal over cottonseed meal is very apparent both in the lots getting clover and in those getting alfalfa. In fact these figures indicate that the use of cottonseed meal with alfalfa hay is not justified, and that it would only be justified with clover when corn was relatively high and cottonseed meal unusually cheap. It should be mentioned that the amount of these nitrogenous concentrates fed daily averaged about 2.5 pounds per 1000 pounds live weight. Probably a better showing would have been made for cottonseed meal if it had been fed in smaller amounts. (Experiments conducted at the Indiana Experiment Station indicate that when fed with clover hay 1.25 pounds of cottonseed meal gives practically as good results as 2.5 per 1000 pounds live weight. Indiana Bulletin. 153)

Comparing clover and alfalfa hay when fed with corn alone and also when fed with nitrogenous supplements it is seen that the use of alfalfa instead of clover will result in a saving of approximately 30 per cent of the corn when no nitrogenous supplement is fed and from 12 - 16 per cent of the corn and 30 per cent of the supplement when a nitrogenous concentrate is included in the ration.

The use of cottonseed meal will result in a saving of 20 per cent of the corn with clover but only 6 or 7 per cent with alfalfa. However, the amount of cottonseed meal used to replace this corn is so great as to practically preclude its economical use especially in the amounts general fed, (2.5 pounds per 1000 pounds live weight.)

The use of linseed oil meal will result in a saving of from 25 to 30 per cent of the corn and approximately 20 per cent of the hay. Since the quantity of this feed used to replace these amounts is relatively small (25 per cent of corn saved in case of clover and 50 per cent for alfalfa), the use of linseed oil meal is usually well justified.

It perhaps should be mentioned that the statements made above with reference to the relative value of the feeds compared differ considerably from the opinion held by many investigators,as well as by cattle feeders in general. It is commonly believed that the advantages possessed by alfalfa over clover and by linseed oil meal over cottonseed meal are slight and of but little consequence in actual feeding practice. Such belief is due largely to the custom of determining the value of a feed solely upon the money profit that results from its use. It is useless to say that cottonseed meal and linseed oil meal are equally desirable in a ration merely because the money profit remains the same regardless which one is used. The very fact that linseed oil meal commands a higher price on the market than cottonseed meal shows that feeders recognize its superior merit. The truth of the matter is that its superiority has resulted in such a large demand that its cost price is advanced to a point where it possesses no "financial advantage" over cottonseed meal. The same statements apply equally well to alfalfa and clover.

Nutrients per Pound Gain.

The protein of cottonseed meal does not seem to be well utilized by the cattle; at least, not in the amount in which it was fed. A surplus of protein exists in both cottonseed groups as shown by the large amount of digestible protein present in the ration per pound of gain made. In the other groups the amount of protein was practically constant for each pound increase in live weight.

The total digestible nutrients consumed per pound gain are in almost exactly the same ratio as the amount of grain eaten per pound of gain. Since the hay consumed in all lots (except those getting oil meal) was practically the same, such an agreement is to be expected. The closeness of it, however, is rather unusual and emphasizes the reliability of the table of digestible

nutrients given in published tables of feed analyses.

Total grain per pound gain 9.07 : 8.5 : 7.3 : 6.9 : 7.35 : 6.10

Total digestible nutrient
per pound gain 9.07 : 8.5 : 7.3 : 7.5 : 7.2 : 5.85

(Reduced to same index)

Pork Produced.

Apparently no definite relation exists between the amount of corn or total grain eaten per pound of gain and the amount of pork produced per bushel of corn fed the cattle. Such a general relation does hold good, however, and with but one or two exceptions those lots using the most grain per pound of gain produced the most pork, while the cattle that used their grain economically had little feed in their droppings to produce gains in hogs. Much less pork was obtained from alfalfa hay rations than from clover. Evidently alfalfa enables a steer to make better use of his grain. The poor showing made by the cottonseed meal in producing gains on cattle in the alfalfa lots is explained by the pork results. Evidently it was not needed by the cattle and was utilized largely by the hogs.

Table IIa. Replacement Value of Feeds

		Corn and Clover	Corn CSM Clover	Corn LSOM Clover	Corn Alfalfa	Corn CSM Alfalfa	Corn LSOM Alfalfa
Alone with corn	Clover				+1.04 T alfalfa - 17 bu. corn	+1.0 T alfalfa + .2 CSM -20.5 bu. corn	+.78 T alfalfa +.16 T LSOM - 29 bu. corn
	Alfalfa	+.96 T clover +16.4 bu. corn	+.98 T clover +.255 T CSM +2.5 bu. corn	+.8 T clover +.2 T LSOM -4.5 bu. corn			
With nitrogenous concentrate	Clover					+1.0 T alfalfa -.07 T CSM -6.0 bu. corn	+.93 T alfalfa -.06 T LSOM -9.0 bu. corn
	Alfalfa		+1.0 T clover +.07 T CSM +6.0 bu. corn	+1.07 T clover +.065 T LSOM +9.5 bu. corn			
	C.S.M.	+.04 T clover +53.7 bu.corn		-.65 T clover +.80 T LSOM - 28 bu. corn	+.25 T alfalfa + 14 bu. corn		-1.07 T alfalfa +.85 T LSOM - 45 bu. corn
	L.S.O.M.	+.75 T clover +100 bu. corn	+.8 T clover +1.25 T CSM + 34 bu. corn		+1.56 T alfalfa + 71 bu. corn	++1.25 T alfalfa +1.2 T CSM +57.5 bu. corn	

Explanation of Table IIa.

This table is constructed on the same principles as Table Ia. The feeds given in the vertical column at the extreme left are the feeds which when substituted for the feeds (except corn) at the head of the vertical column replace the amounts of feeds shown in the squares at the intersection of the vertical column and horizontal lines. For example, when clover alone is fed with corn instead of the combination cottonseed meal and alfalfa, each ton of clover used will replace one ton of alfalfa and .2 tons of cottonseed meal, but will necessitate the use of 20.5 bushels more corn. When clover replaces the alfalfa, the cottonseed part of the ration remaining, each ton of clover used will replace one ton of alfalfa, but will necessitate the use of .07 tons additional cottonseed meal and 6.0 bushels more corn.

Lastly, the addition of cottonseed meal to a ratio of corn and alfalfa will replace .25 tons of alfalfa and 14 bushels of corn for each ton of cottonseed meal used. From these facts it follows that a substitution can be made with profit only when the cost of the feeding stuffs introduced is less than the value of the feeds replaced. In this connection, however, it should be kept in mind that such changes will in all probability influence slightly the rate of gains and consequently the finish obtained during a feeding period of given length. The probable amount of such variations in rate of gain can be ascertained from Table II.

Table IIb

	Corn $.50 Clover $16	Corn $.50 CSM $30 Clover $16	Corn $.50 LSOM $40 Clover $16	Corn $.50 Alfalfa $20	Corn $.50 CSM $30 Alfalfa $20	Corn $.50 LSOM $40 Alfalfa $20
Clover				$12.30	$11.75	$7.50
Alfalfa	$23.56	$24.58	$18.55			
Clover					$14.90	$11.70
Alfalfa		$21.10	$24.47			
CSM	$27.49		$ 7.60	$12.00		$ 9.90
LSOM	$62.00	$67.30		$66.70	$89.75	

From this table it appears that the ordinary market prices of the feeds under discussion are not good indices of their feeding value. Using methods similar to those followed in the preparation of Table Ic we shall attempt to find values for these feeds that will express rather accurately their value in a ration.

From Table IIa we get the following equations.

$1 \text{ ton CSM} = .04 \text{ ton clover} + 53.7 \text{ bushels corn}$ (1)

$1 \text{ ton CSM} = .25 \text{ ton alfalfa} + 14 \text{ bushels corn}$ (2)

Substituting the values, $1 \text{ ton clover} = 25.4 \text{ bushels corn}$ and $1 \text{ ton alfalfa} = 41.3 \text{ bushels corn}$, (page 23),

$1 \text{ ton CSM} = .04\,(25.4\text{ n}) + 53.7\text{ n} = 55\text{ n}$ (3)

$1 \text{ ton CSM} = .25\,(41.3\text{ n}) + 14\text{ n} = 24.3\text{ n}$ (4)

Therefore, we draw the conclusion that when introduced into a ration of corn and clover hay one ton of cottonseed meal has a feeding value equal to 55 bushels of corn; and when into a ration of corn and alfalfa hay a feeding value equal to 24.3 bushels of corn. With corn at $.50 a bushel, we get the following true values for the other feeds:

Corn	$ .50 per bushel	Corn	$ .50 per bushel
CSM	$27.50 per ton	CSM	$ 12.15 per ton
Clover	$12.70 per ton	Alfalfa	$ 20.65 per ton

In a similar manner we can calculate the feeding value of linseed oil meal in terms of bushels of corn, both when it is fed with corn and clover and with corn and alfalfa. These values are found to be as follows:

1 ton LSOM (when fed with corn and clover) = 120 n (5)

1 ton LSOM (when fed with corn and alfalfa) = 135 n (6)

Corn	.50 per bushel	Corn	.50 per bushel
LSOM	$60.00 per ton	LSOM	$67.50 per ton
Clover	12.70 per ton	Alfalfa	20.65 per ton

We shall use these values in making Table IIc.

Table IIc

	Corn $.50 Clover $12.70	Corn $.50 CSM $27.50 Clover $12.70	Corn $.50 LSOM $60 Clover $12.70	Corn $.50 Alfalfa $20.65	Corn $.50 CSM $12.15 Alfalfa $20.65	Corn $.50 LSOM $67.50 Alfalfa $20.65
Clover				$12.97	$12.83	$12.41
Alfalfa	$20.39	$20.71	$19.91			
Clover					$16.78	$10.65 *
Alfalfa		$17.75	$21.73			*
CSM	$27.35		$26.35	$12.16		$12.78
LSOM	$59.52	$61.53		$67.71	$69.14	

Here we find a much more harmonious set of values for the feeds in the left hand column than we had in Table IIb. When fed with corn and clover, cottonseed meal has a feeding value not far from its market price, but when alfalfa is the roughage fed, its use at ordinary market prices would not be at all justified. The feeding value of linseed oil meal, on the other hand, is much above its normal market price when fed with either of the common legume

hays.

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* When alfalfa is substituted for clover in a ration containing corn and a nitrogenous concentrate, only part of the nitrogenous concentrate is displaced. The feeding value of the part remaining is changed, though the above table does not show this fact, consequently the values in these two lines have little value.

III. CORN, NITROGENOUS FEEDINGSTUFFS, AND SILAGE

Extensive use of corn silage in beef cattle experimental feeding began about 1905. At that time it was generally believed that silage was mainly a feed for dairy cows. It was feared that its succulent nature would result in marked laxness of the bowels, a very undesirable condition for steers on full feed, since it precludes rapid and economical gains. However, beef cattle investigators, pushing out vigorously into unknown fields, siezed upon silage as a feed about which more information should be had. It was fast beccming popular with dairymen, and it was but natural that it should be looked upon as a possible home grown feed for beef cattle as well.

Silage being a carbonaceous material should be supplemented with some feed rather high in protein. This protein may be supplied in the form of a legume hay, in the form of a nitrogenous concentrate, or in a combination of these two forms. The object of Table III is to determine the comparative value of these different protein feedingstuffs when fed with silage.

Table III. Comparison of Nitrogenous Feedingstuffs When Fed With Silage

	1 Corn Clover Silage	2 Corn C.S.M. Clover Silage	3 Corn Alfalfa Silage	4 Corn C.S.M. Alfalfa Silage	5 Corn L.S.O.M. Alfalfa Silage	6 Corn C.S.M. Silage
No. of stations	3	2	3	5	3	3
No. of seasons	6	14	6	7	5	5
No. of lots	7	23	10	19	13	10
No. of cattle	65	215	92	142	92	107
Ave. time fed	141	151	133	136	140	150
Ave. daily gain	2.05 ± .17	2.49 ± .19	2.13 ± .16	2.57 ± .25	2.78 ± .21	2.29 ± .18
Feed per lb. gain						
Corn	7.28	6.11	6.19	6.00	5.26	5.91
N. Conc.		1.15		1.03	.86	1.10
Hay	1.92	1.59	2.07	1.08	.68	
Silage	12.61	9.31	8.98	8.70	10.63	12.58
Lbs. dig. protein per lb. gain	.83	1.07	.78	1.00	.84	.95
Total dig. nutrient per lb. gain	9.42	8.56	7.97	8.02	7.40	8.12
Lbs. dig. true protein per lb. gain	.75	1.02	.68	.95	.77	.94
Total net energy per lb. gain	9.17	8.31	7.54	8.01	7.33	7.50
Daily corn eaten	14.7	15.3	13.8	15.25	14.6	13.5
Pork per bushel corn fed cattle	1.56	1.85	1.25	1.69	1.52	1.53

Daily Gains.

The size of the daily gains depends almost entirely upon the per cent of digestible nutrients contained in the nitrogenous feeds used. For example, linseed oil meal and alfalfa, both of which are very high in digestible nutrients as well as protein, give the largest daily gains, while cottonseed meal and alfalfa give the second highest result. Then follow cottonseed meal and clover, cottonseed meal alone, alfalfa alone, and clover alone. It should be remarked that but one record was found where linseed oil meal and clover were fed to two-year-old cattle for a period exceeding 100 days. The daily gains of this one lot were very large, 3.16 pounds. This result, however, must be regarded as unusual and we should expect the average daily gains for a ration containing these feeds to exceed slightly those for cottonseed meal and alfalfa. Such a prediction is based upon the results of Table II as well as upon the total pounds of digestible nutrients in equal quantities of linseed meal and clover and cottonseed meal and alfalfa. Also but one case was found where linseed oil meal was the only nitrogenous feed used with silage. The daily gains in this case were rather low, 2.01 pounds. Under ordinary conditions we should expect this combination to give results somewhat higher than cottonseed meal and silage.

It is apparent that a ration containing a considerable amount of silage cannot be properly balanced by the addition of a legume hay. Neither can a ration having only silage as a roughage be perfected simply by the addition of a nitrogenous concentrate. Evidently the legume roughage performs some other function than simply supplying some of the necessary protein.

Index numbers for daily gains are as follows: (When fed with corn and silage.)

Clover 89.5; Alfalfa 93; Cottonseed meal 100.

Cottonseed meal and clover 109; Cottonseed meal and alfalfa 112; Linseed oil meal and alfalfa 121.5.

Time required to realize 300 pounds increase in weight:

Clover 146 days; Alfalfa 141; Cottonseed meal 131.

Cottonseed meal and clover 120; Cottonseed meal and alfalfa 117; Linseed oil meal and alfalfa 108.

Feed per Pound Gain.

The addition of a nitrogenous concentrate to a ration of corn, clover, and silage resulted in a reduction in the amount of corn used per pound gain equal to the amount of protein supplement fed. In addition the quantity of clover was reduced 17 per cent and the silage slightly over 25 per cent. With alfalfa much smaller reductions were noticed. Such a difference is to be expected, since alfalfa being higher in nitrogen than clover, does not need the addition of cottonseed meal so badly as does clover. The use of oilmeal resulted in a marked reduction in the amount of corn and hay used in producing a pound of gain, though the amount of silage was slightly increased. Such varaitions in the amounts of the individual feeds should not be taken too seriously. They result largely from slight variations in the proportion in which the different feeds are fed by the different experiment stations. Consequently, the total amount of all feeds rather than the amount of any particular feed eaten per pound of gain is the important fact to consider. While the amount of silage in column 5 is somewhat higher than in column 3 or 4, the small amount of hay eaten in column 5 results in as low a consumption of total roughage as in either of the others. Comparing column 4 with column 6, it is seen that one pound of alfalfa has almost exactly the same feeding value as 3 1/2 pounds of silage, and that these feeds can be substituted for each other in limited amounts without affecting perceptibly the amount of

concentrates necessary to produce a pound of gain. Similarly, columns 2 and 6 show that one pound of clover will replace approximately two pounds of silage without greatly affecting the efficiency of the ration. These facts will be brought out more clearly in the discussion under the heading "Replacement of Feeds."

Digestible Nutrients.

In general the total digestible nutrients per pound gain can be arranged in the same order as the feed per pound gain, or in inverse order from the daily gains per head. The ration requiring the lowest amount of total digestible nutrients stands at the bottom in feed per pound gain, but at the top in daily gains per head. Likewise the ration having the highest amount of total digestible nutrients stands at the top in feed per pound gain, but is lowest in the daily gains per head. Values in between these extremes do not agree so well, but with but one or two exceptions, they emphasize the fact that rapid and economical gains are synonymous, both as to actual weight of feed eaten and as to the total amount of total digestible nutrients consumed.

Pork Produced Behind Cattle.

Pork however does not follow the amount of total digestible nutrients necessary to produce a pound of gain so closely as it does the amount of crude protein eaten to accomplish this result. The following table shows the close relationship that exists between the amount of pork produced by the hogs and the amount of crude protein consumed by the cattle per pound gain.

Crude Protein Consumed by the Cattle per Pound Gain

	Crude protein per lb. gain	Pork per bushel corn fed cattle	Ratio
Alfalfa	.78	1.25	1.60
Clover	.83	1.56	1.88
Linseed oil meal and alfalfa	.84	1.52	1.82
Cottonseed meal	.95	1.53	1.61
Cottonseed meal and alfalfa	1.00	1.69	1.69
Cottonseed meal and clover	1.07	1.85	1.73

With but one exception the rations assume the same ratings for the amount of pork produced as they do for the amount of protein consumed per pound gain.

Replacement Value of Feeds

Table IIIa. Replacement Value of Nitrogenous Feedingstuffs When Fed With Silage

1 ton		Corn Clover Silage	Corn CSM Clover Silage	Corn Alfalfa Silage	Corn CSM Alfalfa Silage	Corn LSOM Alfalfa Silage	Corn CSM Silage
Without nitrogenous concentrate	Clover			+1.08 T alfalfa -1.90 T silage - 20 bu. corn	+.45 T CSM +.56 T alfalfa -2.00 T silage -24 bu. corn	+.45 T LSOM +.35 T alfalfa -1.00 T silage -3.75 bu. corn	+.57 T CSM -25 bu. corn
	Alfalfa	+ 19 bu. corn +1.75 T silage + .90 T clover	+.50 T CSM +.77 T clover .15 T silage				+.53 T CSM +1.75 T silage -5 bu. corn
With nitrogenous concentrate	Clover				+.68 T alfalfa -.4 T silage -.07 T CSM -2.5 bu. corn	No data	+2.0 silage -.03 T CSM -4.5 bu. corn
	Alfalfa		+1.50 T clover + .10 T CSM + .60 T silage +3.50 bu. corn				+3.6 T silage +.06 T CSM -3.0 bu. corn
C.S.M.		+3.0 silage + .3 clover +36.0 bu. corn		+1.0 T alfalfa + .10 T CSM + .60 T silage +3.50 bu. corn		+.83 T LSOM +1.85 T silage -,4 T alfalfa -25 bu. corn	
L.S.O.M.		No data	No data	+1.6 T alfalfa +38.5 bu. corn - 1.9 T silage	+1.2 T CSM +.45 T alfalfa + 31 bu. corn -2.25 T silage		No data

Table IIIa strikingly emphasizes the superiority of alfalfa hay over clover from the standpoint of economy of gains. It is extremely unlikely that the difference in the market prices of these two legume hays will ever be sufficient to make clover the chepaer feed to use from the standpoint of economy of gains. With average feed prices, (see Note A), alfalfa is worth practically twice as much per ton as clover based upon the value of the feeds saved when one ton of alfalfa is introduced into the ration and clover is withdrawn. Similarly linseed oil meal has practically twice the value of cottonseed meal based upon the market price of the feeds saved when the former is substituted for the latter. (See Note B.)

Note A

Market price of feeds:

Corn $.50 per bushel

Cottonseed meal $30 per ton

Clover $15 per ton

Silage $4.50 per ton

Example No. 1. 1 ton alfalfa saves

(19 bushels corn	$9.50
(1.75 tons silage	7.88
(.90 tons clover	13.50
Total	$30.88

Example No. 2. 1 ton alfalfa saves

(1.50 tons clover	$22.50
(.10 tons C.S.M.	3.00
(.60 tons silage	2.70
(3.50 bushels corn	1.75
Total	$29.95

Note B

Alfalfa $20 per ton

Example No. 3. 1 ton linseed oil meal + 2.25 tons silage saves

(1.2 tons C.S.M.	$ 36.00
(.45 tons alfalfa	9.00
(31.0 bushels corn	15.50
	60.50
2.25 tons silage	10.12
Total value of 1 ton LSOM	$50.38

(.4 Ton alfalfa) (.83 ton LSOM $33.20
Example No. 4. 1 ton CSM + (25 bushels corn) saves (1.85 ton silage 8.33
(LSOM $40) $41.53

.4 ton alfalfa $8.00
25 bushels corn 12.50 20.50
Total value of 1 ton CSM $ 21.03

IV. DRY ROUGHAGE WITH SILAGE

It is not uncommon for cattle feeders to use corn silage as the sole roughage part of the ration. Considerable experimental work has been done on the benefit to be derived from the substitution of a dry roughage for part or all of the silage. Table III, which has just been discussed, makes a comparison of an exclusive silage roughage and a roughage composed of silage and either clover or alfalfa hay. Table IV carries this sort of comparison one step further by adding rations in which all of the silage has been replaced by either clover or alfalfa. Two years work at the Illinois Station with two-year-old cattle indicated that while the gains were somewhat more rapid with a dry roughage than with silage alone, the cost of gains varied inversely with the amount of silage used, being lowest when silage formed the sole roughage and highest when no silage at all was fed. Lots of cattle fed two-thirds and one-third of their roughage in the form of silage had costs of gains lying between the costs for the "all silage" and "no silage" lots. Unfortunately, these two years of work at this one station are all the trials that have been found where such a variation was made in the dry roughage and silage fed. However, there are many records of trials where silage was fed alone, where it was fed with alfalfa or clover in different proportions, (probably no two exactly the same, especially at different stations), and where no silage at all was fed, the roughage being exclusively clover or alfalfa hay. The average results of such rations are given in Table IV.

Table IV. Comparison of Dry Roughage When Fed With Silage

	1 Corn CSM Silage	2 Corn CSM Clover Silage	3 Corn CSM Alfalfa Silage	4 Corn CSM Clover	5 Corn CSM Alfalfa
Number of stations	3	2	5	1	3
Number of seasons	5	14	7	10	6
Number of lots	10	23	19	11	10
Number of cattle	107	215	142	115	97
Average time fed	150	151	136	160	139
Ave. daily gain	2.29 ±.18	2.49±.19	2.57±.25	2.40±.11	2.53±.23
Feed per lb. gain					
Corn	5.91	6.11	6.00	7.25	6.46
CSM	1.10	1.15	1.03	1.21	.89
Hay		1.59	1.08	4.61	4.51
Silage	12.58	9.31	8.70		
Lbs. dig. crude protein per lb. gain	.95	1.07	1.00	1.29	1.26
Total dig. nutrients per lb. gain	8.12	8.56	8.02	9.47	8.53
Lbs. dig. true protein per lb. gain	.94	1.02	.95	1.17	1.06
Total net energy per lb. gain	7.50	8.31	8.01	9.06	8.03
Ave. corn per day	13.5	15.3	15.25	17.5	16.30
Pork per bu. of corn fed cattle	1.53	1.85	1.69	1.44	1.56

Daily Gains.

Neither silage nor a legume hay will give so rapid gains as will a mixture of the two roughages. No explanation of this fact is to be found in a study of the amounts of digestible protein or total digestible nutrients in the rations concerned, Evidently a combination of these roughages possesses certain advantages apart from the absolute food nutrients that each contains. Aside from the fact that a mixture of feeds affords palatability, is the likelihood that the presence of a certain feed increases the digestibility of the ration as a whole, because of the effect of the feed upon both the physical and chemical condition of the feed as it passes through the alimentary tract. It will be noticed that gains from alfalfa, both when fed as the sole roughage and when fed with silage, are noticeably larger than the gains from corresponding rations of clover. Since this fact has appeared and been discussed in both Tables II and III, no further comment is necessary on this point.

Index numbers for daily gains are as follows: (When fed with corn and cottonseed meal).

Silage 100; clover and silage 109; alfalfa and silage 112; clover 105; alfalfa 110.5.

Days required to realize 300 pounds increase in weight:

Silage 130; clover and silage 120; alfalfa and silage 117; clover 125, alfalfa 118.5.

Feed Per Pound Gain.

The amount of grain required per pound of gain varies inversely as the amount of silage fed. Or to put it the other way round, the substitution of a legume roughage for part or all of the silage resulted in an increase in the amount of grain required per pound of gain. This result was to be expected since silage itself contains no inconsiderable amount of corn. However, the

increase in the grain part of the ration is in no case equal to the amount of corn that may properly be assumed to have been present in the silage displaced. Consequently, the legume hay added must be regarded as a substitute for most of the grain as well as all of the roughage in the silage withdrawn.

Table IVa. Silage Replaced by Legume Hay

	1 All silage vs. part silage part clover	2 All silage vs. all clover	3 All silage vs. part silage part alfalfa	4 All silage vs. all alfalfa
Silage withdrawn	3.27 lbs.	12.58 lbs.	3.88 lbs.	12.58 lbs.
Probable grain (corn) withdrawn in silage*	.46	1.76	.54	1.76
Grain added	.25	1.45	.02	.34
Grain replaced by legume	.21	.31	.52	1.42
Grain replaced per pound of legume	.13	.067	.48	.31
Total silage replaced per pound of legume	2.06	2.73	3.60	2.79
Average silage replaced per pound of legume	2.40		3.20	

* (Assuming 5 bushels of corn in each ton of silage).

Thus we see that the legume hay introduced into the ration took the place of a large amount of the grain that was in the silage as well as replacing all of the roughage represented by the silage withdrawn. Again the superiority possessed by alfalfa over clover is apparent.

Digestive Nutrients.

With the exception of the ration having silage as the sole roughage, the total digestible nutrients consumed per pound gain arrange themselves in

the inverse order from that of the daily gains per head. All figures for the corn, cottonseed meal, silage ration, however, are very much out of line with the other results, all being much lower than the average daily gain or the feed per pound gain would lead one to expect. It is entirely possible that the explanation of the low values for this ration lies in the fact that the figures given for the digestible nutrients and net energy of silage in feeding standards are entirely too low. The compilers of such standards often freely admit that the figures given for silage are based upon data too incomplete to be regarded as conclusive. There can be no question that the results of actual feeding trials assign a much higher feeding value to silage than is represented by its reported chemical composition.

Pork Produced Behind Cattle.

No good agreement seems to exist between the amounts of pork produced per bushel of corn fed and any other figures given in the table. If we except the "all silage" lots, we might say that the presence of corn silage had a tendency to increase the amount of pork made by pigs following cattle. Since no good reason can be assigned for not including this lot, it would be better to say that the presence of silage in a ration does not appear to affect the amount of pork produced.

Table IVb. Replacement Value of Clover, Alfalfa, and Silage

1 ton lot		Corn CSM Silage	Corn CSM Clover Silage	Corn CSM Alfalfa Silage	Corn CSM Clover	Corn CSM Alfalfa
Substituted for all of other kind of roughage present	Clover	+2.6 T silage -.02 T CSM - 10 bu. corn	+3.08 T silage -.046 T CSM -13.0 bu. corn			
	Alfalfa	+2.8 T silage +.05 T CSM -4.50 bu. corn		+2.54 T silage +.04 T CSM -4.8 bu. corn		
	Silage		+.50 T clover +.01 T CSM +2.0 bu. corn	+.28 T alfalfa +1.00 bu.corn -.02 T CSM	+.37 T clover +.01 T CSM +3.8 bu. corn	+.36 T alfalfa +1.5 bu. corn -.02 T CSM
Substituted for part of other kind of roughage present	Clover	+2.00 T silage - .03 T CSM -4.50 bu. corn				
	Alfalfa	+3.6 T silage + .06 T CSM -3 bu corn				
	Silage				+.32 T clover + 4 bu. corn	+ .4 T alfalfa +2.0 bu. corn -.02 T CSM

Following the method used in connection with previous tables we shall attempt to work out a value for silage per ton expressed in so many bushels of corn. It will be recalled that the value of cottonseed meal was different when used with corn and alfalfa from the value it appeared to have when used with corn and clover. These values will be adopted in the following calculations. It may develop that silage also has a certain value when fed with alfalfa but a different value when fed with clover. Consequently, we shall make two separate computations for silage, first, when substituted for part or all of the clover; and second, when it replaces part or all of the alfalfa.

From column 4, 1 ton silage = .37 (25.4n) + .01 (55n) + 3.8n = 13.75n

From column 2, 1 ton silage = .50 (25.4n) + .01 (55n) + 2n = 15.25n

From column 4, 1 ton silage = .32 (25.4n) + 4n = 12.13n

From column 1, 2.6 ton silage = 25.4n + .02 (55n) + 10n

1 ton silage = 14n

From column 2, 3.08 ton silage = 25.4n + .046 (55n) + 13n

1 ton silage = 13.3n

From column 1 2.00 ton silage = 25.4n + .03 (55n) + 4.5n

1 ton silage = 15.7n

Average value silage per ton (when substituted for clover) 14.02n

Similarly for silage substituted for alfalfa we get the following:

From column 1, line 2, 1 ton silage = 15.9n

From column 1, line 5, 1 ton silage = 11.9n

From column 3, line 2, 1 ton silage = 17.7n

From column 3, line 3, 1 ton silage = 12.1n

From column 5, line 3, 1 ton silage = 15.9n

From column 5, line 6, 1 ton silage = 18.0n

Average value silage per ton (when substituted for alfalfa) = 15.25n

There appears to be considerably more variation in the value of silage substituted for alfalfa than of silage substituted for clover. The averages for each, however, are not far apart, and it would not be far from the truth so say that one ton of silage has a feeding value that is approximately the same as 15 bushels of corn, This is the value that will be used for silage in constructing Table IVb. When corn is $.50 a bushel, silage will have a value of $7.50 per ton.

Table IVb. Replacement of Clover, Alfalfa, and Silage Expressed in Money (Revised Values)

1 ton	Corn $.50 CSM $27.50 Silage $7.50	Corn $.50 CSM $27.50 Clover $12.70 Silage $7.50	Corn $.50 CSM $12.15 Alfalfa $20.65 Silage $7.50	Corn $.50 CSM $27.50 Clover $12.70	Corn $.50 CSM $12.15 Alfalfa $20.65
Clover	$13.95	$14.34			
Alfalfa	$19.36		$17.14		
Silage		$ 7.62	$ 6.04	$6.87	$7.93
Clover	$11.93				
Alfalfa	$25.43				
Silage				$6.06	$9.02

While the figures in the above table show rather wide divergence, they are in much closer agreement and are much more rational than those obtained by using ordinary commercial prices for the feedingstuffs. Ordinary prices are used in making Table IVc where we find the replacement values of the feeds not even approaching the commonly accepted market values.

Table IVc. Replacement Value of Clover, Alfalfa, and Silage Expressed in Money (Market Values)

1 ton		Corn $.50 CSM $30 Silage $4.50	Corn $.50 CSM $30 Clover $16 Silage $4.50	Corn $.50 CSM $30 Alfalfa $20 Silage $4.50	Corn $.50 CSM $30 Clover $16	Corn $.50 CSM $30 Alfalfa $20
Substituted for all of other kind of roughage	(Clover	$6.10	$4.98			
	(Alfalfa	11.85		$10.23		
	(Silage		$9.30	$ 5.50	$8.12	$7.35
Substituted for part of other kind of roughage	(Clover	$5.85				
	(Alfalfa	16.50				
	(Silage				$7.12	$8.40

V. DIFFERENT DRY ROUGHAGES WITH SILAGE

The advantages to be derived from feeding silage and a legume hay together, rather than one of them alone, have been discussed in Part IV. It will be recalled that rations containing both of these roughages produced more rapid gains with less digestible nutrients per pound gain than rations containing but a single roughage constituent. The question now arises, are these advantages due to an improvement in the chemical composition of the ration; or do they arise from a better physical mixture of dry and succulent materials that can be more easily acted upon by the digestive processes? A comparison of rations in which silage is combined with various kinds of dry roughages, differing in both chemical composition and physical properties ought to throw some light upon this point. Such a comparison is made in Table V.

Table V. Comparison of Dry Roughage With Silage

	1 Corn CSM Silage	2 Corn CSM Alfalfa Silage	3 Corn CSM Clover Silage	4 Corn CSM Mixed hay Silage	5 a Corn CSM Mixed hay Stover Silage	6 Corn CSM Oat straw Silage
Number of stations	3	5	2	2	1	1
Number of seasons	5	7	14	6	3	3
Number of lots	10	19	23	7	7	4
Number of cattle	107	142	215	50	78	39
Average time fed	150	136	151	133	128	169
Ave. daily gain	2.29±.18	2.57±.25	2.49±.19	2.17±.12	2.12±.15	2.38
Feed per lb. gain						
Corn	5.91	6.00	6.11	5.10	6.85	5.80
Nitrogenous Concentrate	1.10	1.03	1.15	1.26	1.00	1.17
Hay		1.08	1.59	2.06	.97	
Stover or straw					1.47	.91
Silage	12.58	8.70	9.31	12.09	9.00	9.79
Lbs. dig. protein per lb. gain	.95	1.00	1.07	1.01	1.00	.94
Total dig. nutrients per lb. gain	8.12	8.02	8.56	8.36	9.06	8.01
Lbs. dig. true protein per lb. gain	.94	.95	1.02	1.01	.98	.93
Net energy per lb. gain	7.50	8.01	8.31	8.27	8.97	7.94
Corn eaten daily	13.5	15.25	15.3	11.0	14.80	14.2
Pork per bu. of corn fed cattle	1.53	1.69	1.85	1.62		1.63

(a. See Palatability of Stover, page 63)

Some doubt is felt about the advisability of including the results from the cattle fed mixed hay and silage because of the small amount of corn that they received. Two lots out of the seven received a little less than 10 pounds of corn daily, (9.8 and 9.9 respectively), but it was thought that this very slight variation from the amount taken as the minimum should not exclude them from consideration, especially since none of the lots of this group received more than 12.8 pounds.While this low consumption of corn has probably affected nearly all of the figures for this group, it was thought better to include them than to leave them out all together. It should be kept in mind, however, that they are not strictly comparable with the figures given for the other groups.

Daily Gains.

No good explanation appears for the low gains made by the cattle getting mixed hay, stover, and silage for roughage. Unlike the mixed hay, silage group, they received a liberal feed of corn. The comparatively short time they were on feed, moreover, would tend to result in a good showing in daily gains. However, they have decidedly the smallest gains shown in this table. The figure given, while low, must be taken as fairly accurate, since but two of the seven lots made gains appreciably above the average. The small probable error shows that the daily gains of this group were fairly uniform in size.

Excepting the mixed hay, it is seen that while the addition of any dry roughage to silage results in an increase in rate of gain, the amount of this increase is closely related to the amount of protein contained in the dry roughage introduced. The protein contained in the small amount of oats straw fed could hardly account for the increase in gain of nearly one-tenth of a pound over the group getting no dry roughage. Hence, it seems reasonable to

suppose that the dry roughage is useful in improving the physical character of the ration. That it is useful also as a source of food nutrients is shown by the still larger daily gains in the groups receiving alfalfa and clover.

Index numbers for daily gains are as follows: (When fed with corn and cottonseed meal).

Silage 100; silage and straw 104; silage and clover 109; silage and alfalfa 112; (Silage and mixed hay 95)[a] silage, mixed hay and stover 92.

Days required to realize 300 pounds increase in weight:

Silage 131; silage and straw 126; silage and clover 120; silage and alfalfa 117; (Silage and mixed hay 138)[a] silage, mixed hay, and stover 141.

Feed per Pound Gain.

The effect of the addition of a dry roughage on the amount of grain eaten per pound gain is practically negligible. Except in the lots getting mixed hay, approximately seven pounds of grain are required per pound of gain. Due to the small amount of grain fed in the mixed hay, silage group, the corresponding figure here is somewhat lower. The addition of stover to a roughage combination of mixed hay and silage apparently resulted in too great an amount of dry roughage, hindering instead of aiding the processes of digestion. Such an assumpsion at least seems reasonable in the face of the unusual high grain consumption per pound gain where stover was used.

The addition of dry roughage noticeably decreased the amount of silage, on an average about what we should expect. There is a feeling on the part of cattlemen that one pound of dry roughage is equivalent to two pounds of silage. The exact ratio as determined in the following table is 1 : 2.18.

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a. Possibly not reliable.

Table Va. Silage Replaced by Dry Roughage

Based on feed per pound gain. Silage sole roughage.	1 Corn CSM Alfalfa Silage	2 Corn CSM Clover Silage	3[b] Corn CSM Mixed hay Silage	4 Corn CSM Mixed hay Stover Silage	5 Corn CSM Oats straw Silage
Silage replaced	3.88	3.27	.49	3.58	2.79
Probable grain (corn)* in replaced silage	.54	.46	.07	.50	.39
Grain added	.02	.25	-.65	.84	-.04
Grain replaced by dry roughage	.52	.21	.72	-.34	.43
Grain replaced per pound dry roughage	.48	.13	.35	-.18	.47
Total silage replaced per pound dry roughage	3.60	2.06	.23	1.93	3.07
Average silage replaced per pound dry roughage			2.18		

* Assuming 5 bushels of corn per ton of silage.

Digestible Nutrients.

A study of the amount of total digestible nutrients per pound gain throws some light upon the comparative efficiency of the different dry roughages. Here, as in all preceding tables, we find that the total digestible nutrients tend to arrange themselves in inverse order from that of the daily gains per head. The low gains made in the mixed hay group are explained by the inefficiency of the rations used. It is rather surprising to find mixed hay a poorer feed than oats straw; yet an explanation of the fact is not impossible. "Mixed hay"usually is made up largely of timothy. Possibly the hay in question was not more than ten per cent clover. Consequently, in chemical composition it did not differ much from oats straw. However, two and

a quarter times as much mixed hay (timothy?) was fed per pound gain as oats straw. Thus not only was the dry roughage requirement satisfied, but the large consumption of hay resulted in an excess of dry material that possibly tended to overburden the digestive system, lessening the digestibility of the other components of the ration. The presence of the stover in the mixed hay - stover - silage group apparently had the same effect as the surplus mixed hay in the group just discussed. It is possible that the withdrawal of either the mixed hay or the stover would have greatly improved the ration.

Pork Produced Behind Cattle.

The addition of any dry roughage to a ration containing silage apparently increases the amount of pork produced by hogs following the cattle. This increase is practically uniform for all dry roughages and is approximately .12 pound per bushel of corn fed or an increase of 8 per cent, based upon the pork produced when no dry roughage was given. A somewhat greater increase resulted upon the addition of clover. This was to be expected since the clover-silage group showed a higher grain consumption and a larger amount of digestible nutrients per pound gain than the daily gains would seem to indicate. Evidently there is no getting around the fact that what goes into a steer much either show up as beef or pork. If data were available on pork for the mixed hay - stover - silage lots, it would in all likelihood show this group at the head of the list in pork production.

Table Vb. Replacement Value of Dry Roughage When Fed With Silage

1 ton	Corn CSM Silage	Corn CSM Alfalfa Silage	Corn CSM Clover Silage	Corn CSM Mixed Hay Silage	Corn CSM Mixed Hay Stover Silage	Corn CSM Oats Straw Silage
Alfalfa	+3.6 T silage + .06 T CSM -3.0 bu. corn		+1.5 T clover + .10 T CSM + .60 T silage +3.5 bu. corn	+2.0 T mixed hay +3.1 T silage + .2 T CSM -30 bu. corn	+.9 T mixed hay +1.4 T stover + .3 T silage +28 bu. corn	+.85 T straw +1.00 T silage + .13 T CSM -6.5 bu. corn
Clover	+2.00 T silage -4.5 bu. corn	+.68 T alfalfa -.4 T silage -.07 T CSM -2.5 bu. corn		+1.3 T mixed hay +1.7 T silage +.07 T CSM -22.5 bu. corn	+.61 T mixed hay +.90 T stover +16.5 bu. corn -.10 T CSM	+.6 T straw +.3 T silage -7.0 bu.corn
Mixed Hay	+.2 T silage +.1 T CSM +14 bu. corn	+.5 T alfalfa +15.5 bu. corn -.1 T CSM -1.65 T silage	+.72 T clover +17.5 bu. corn -.05 T CSM -1.35 T silage			+.4 T stover +13.5 bu. corn -.04 T CSM -1.0 T silage
Stover				+2.1 T silage +.75 T mixed hay +.18 T CSM -42.5 bu. corn		
Straw	+3.0 T silage +3.6 bu. corn -.08 T CSM	+1.2 T alfalfa +8.0 bu. corn -.15 T CSM -1.2 T silage	+1.75 T clover +12 bu. corn -.02 T CSM -.53 T silage	+2.25 T mixed hay +2.50 T silage + .1 T CSM -27.5 bu. corn	+1.0 T mixed hay +1.0 T stover +40 bu. corn -.2 T CSM -.9 T silage	

VI. CORN SILAGE VS. CORN STOVER

Fifteen or twenty years ago extensive use was made of corn stover in fattening cattle for market. It was a common practice to feed the stover and corn together in the form of shock corn, usually supplying in addition some other roughage such as timothy, mixed, or clover hay. After the experiment stations had demonstrated the value of a nitrogenous concentrate in such a ration, the more progressive feeders added either cottonseed or linseed oil meal, especially if the hay fed was not practically straight clover.

With the coming of the silo, there was a general movement on the part of such feeders to silo their corn instead of shocking it, thereby eliminating the high per cent of waste represented by the unconsumed stalks of the stover. Moreover, the silo solved the problem of getting the corn in from the fields during inclement or muddy weather, as well as providing feed during the late spring and summer months when stover is out of season. Through the wide use of the silo and the extensive growing of legumes, the feeding of stover has been much curtailed. However, it has by no means been entirely discarded by the rank and file of cattlemen. Being available in almost unlimited amounts and easily stored, it naturally comes into use when other roughages are scarce and unusually high in price.

Table VI. Comparison of Silage and Corn Stover

	1 Corn CSM Mixed hay Silage	2 Corn CSM Mixed hay Stover	3 Corn CSM Mixed hay Stover Silage
Number of stations	2	1	1
Number of seasons	6	4	3
Number of lots	7	7	7
Number of cattle	50	78	78
Average time fed	133	114	128
Average daily gain	2.17 ± .12	2.03 ± .11	2.12 ± .15
Feed per lb. gain			
Corn	5.10	6.84	6.85
Nitrogenous concentrate	1.26	.91	1.00
Hay	2.06	2.61	.97
Silage	12.09		9.00
Stover		2.47	1.47
Lbs. dig. crude protein per lb. gain	1.01	.95	1.00
Total dig. nutrient per lb. gain	8.36	8.44	9.06
Lbs. dig. true protein per lb. gain	1.01	.91	.98
Total net energy per lb. gain	8.27	8.13	8.97
Average corn per day	11.0	14.0	14.8
Pork per bushel corn fed cattle	1.62		

Palatability of Stover.

The principal objection to stover as a feed for cattle is its high per cent of waste. Cattle show a liking for the leaves and husks of the corn plant but reject the lower two thirds of the stalk wherein a large amount of the weight lies. The per cent of stover refused is decreased somewhat by shredding, but it is by no means eliminated by this process. Most bulletins reporting experiments in which stover was used give simply figures for the amount of stover consumed, explaining in the discussion that "all refused feed was carefully weighed and subtracted from the amount offered the cattle, the difference being taken as the amount consumed." However, data have been found for 11 lots of cattle giving the actual pounds of stover offered and refused. These figures make possible the calculations of the per cent of stover that was actually eaten by the cattle in each of the lots considered. In a few cases attention was called to the fact that the stover was shredded. However, knowledge on this point is insufficient to permit the determination of separate figures for shredded and for ordinary or whole stover. It is possible, however, to divide the stover that was fed with silage from that fed only with dry feedingstuffs.

Table VIa. Percentage of Stover Actually Consumed

	Lot No.	Stover Offered	Stover Refused	Per cent Refused
Without Silage	1	4193	1433	34.6
	2	4162	933	22.4
	3	9479	5080	53.6
	4	9390	3567	38.0
	5	5542	2363	42.6
	6	6720	2014	30.0
	7	6720	2854	42.5
	Total 7 lots	46206	18244	39.5
With Silage	8	3296	1596	48.4
	9	3291	1738	52.8
	10	7679	3321	43.2
	11	7679	2580	33.6
	Total 4 lots	21945	9235	42.1
	Total 11 lots	68151	27479	40.3

The above figures bear out the statement that a considerable part of the stover fed cattle is not eaten. Although the lots receiving silage refused a somewhat larger per cent than did the cattle getting no succulent feed, the difference is rather small and may well be disregarded since it is less than 1 per cent. Consequently, 40 per cent may be considered as representing the approximate waste that is encountered in using stover with cattle on full feed.

In as much as the unconsumed stover is valueless except for bedding, it seems unreasonable to charge cattle with only the amount of stover actually consumed. As a matter of fact, the low market price of stover is based largely on the fact that both buyer and seller recognize that every ton contains

a large amount of material of little or no feeding value. The heavy ends of corn stalks have much the same relation to stover that corn cobs have to ear corn. No experiment station or practical feeder would think of feeding ear corn to hogs and deducting the weight of the cobs from the amount offered to arrive at the amount of ear corn consumed. Likewise, it is illogical to substract the weight of the unconsumed stalks from the amount of stover offered. The cattle should be debited with the entire amount given and the resulting waste disregarded, the same as the cobs of ear corn. This has been done in the preceding table under the heading "Feed per Pound Gain". "Actually consumed" stover has been changed to "total stover offered" by multiplying the former figure by 100/60 or 166 2/3 per cent. In computing the amount of protein and total digestible nutrients per pound gain, however, only the "actually consumed" stover was taken into account.

Daily Gains.

The daily gains vary directly with the amount of silage in the ration. Silage is a good "conditioner" and is naturally conducive to better thrift and vigor than is a dry, more or less constipating feed like stover.

Index numbers of gains:

Silage, 100; stover, 93.5; silage and stover, 97.7.

Days required to realize 300 pounds gain in weight.

Silage, 138; stover, 148; silage and stover, 141.5.

Feed per Pound Gain and Digestible Nutrients.

These topics need little discussion, the figures given in the table being self-explanatory. The group getting both stover and silage exhibits a low efficiency as shown by the amount of feed eaten per pound of gain and by the total nutrients per pound gain. The consumption of corn per pound gain is very high in view of the large amount of silage eaten.

Pork Produced Behind Cattle.

Too few figures on the amount of pork produced are available for the stover fed cattle to justify their use in the table.

Table VIb. Replacement Value of Silage and Corn Stover

	1 ton	Corn CSM Mixed Hay Silage	Corn CSM Mixed Hay Stover	Corn CSM Mixed Hay Stover Silage
When fed alone	Silage		+.20 T stover +.045 T mixed hay +5.0 bu. corn - .03 T CSM	+.48 T stover +20.0 bu. corn -.08 T CSM -.35 T mixed hay
	Stover	+4.9 T silage - .22 T mixed hay + .14 T CSM -25 bu. corn		+9.0 T silage + .09 T CSM -1.64 T mixed hay
When fed together	Silage		+.11 T stover +.18 T mixed hay -.01 T CSM	
	Stover	+2.1 T silage + .75 mixed hay + .18 T CSM -42.5 bu. corn		

VII. MOLASSES AND MOLASSES FEEDS

There has been a tendency of late years to use increasing amounts of manufactured and specially prepared feeds. The reasons for this are not far to seek. There has been a ready sale at high prices of all farm grown grains, especially corn. Cattlemen naturally have looked for something cheaper than corn to take its place in the ration. Likewise, all nitrogenous concentrates have been very dear, selling at almost three times their pre-war values. Feed manufacturers have taken advantage of these unusual conditions and have attempted to sell mixed feeds on the grounds that such feeds would take the place of much corn, as well as much, if not all, of the nitrogenous concentrate.

Many of such feeds contain rather considerable quantities of cane molasses, together with a mixture of such feedingstuffs as cracked corn, crushed oats, cracked barley, wheat and oats screenings, linseed oil or cottonseed meal, chopped alfalfa, and often some inert matter such as oats hulls, or even saw dust or dried peat. Each manufacturer makes his product according to a particular formula usually known only to himself, and offers it for sale under the name of a special trade name or brand. In the table below all manufactured molasses feeds have been grouped together without regard to their actual composition. In addition, rations containing cane molasses as a separate item are considered, and are compared with the rations containing the manufactured molasses feeds as well as with a frequently used ration containing no molasses at all.

Table VII. Comparison of Rations Containing Molasses

	1 Corn CSM Mixed hay Silage	2 Corn Molasses CSM Mixed or legume hay Silage	3 Corn Molasses feed Legume hay Silage	4 Corn Molasses feed Legume hay Silage CSM
Number of stations	2	2	3	1
Number of seasons	6	3	5	2
Number of lots	7	5	7	2
Number of cattle	50	38	53	11
Average time fed	133	144	134	120
Average daily gain	2.17±.12	2.43	2.20±.17	2.45
Feed per pound gain				
Corn	5.10	3.69	4.61	4.13
Molasses		1.65	2.52	1.93
Cottonseed meal	1.26	1.39		1.15
Hay	2.06	1.61	1.31	2.00
Silage	12.09	11.38	13.20	10.08
Lbs. dig. crude protein per pound gain	1.01	.95		
Lbs. total dig. nutrient	8.36	7.93		
Lbs. dig. true protein	1.01			
Net energy per lbs. gain	8.27			
Average corn per day	11.0	8.85	10.93	10.00
Average molasses per day		3.97	5.54	4.73
Pork per bushel of corn fed cattle	1.62	1.35	1.52	1.75

Daily Gains.

The use of molasses unquestionably increases the rate of gain. It is probable that a part of this increase is due to the larger consumption of feed in the molasses fed lots. However, this increase in feed consumption is not sufficient to account for all the difference in rate of gain. Apparently the molasses itself has a beneficial effect upon the thrift and well being of the cattle.

Index of daily gains:

Corn and cottonseed meal 100; corn, molasses and cottonseed meal 112; corn and molasses feed 101; corn, molasses feed and cottonseed meal 113.

Time required to realize 300 pounds gain:

Corn and cottonseed meal 138; corn, molasses and cottonseed meal 123.5; corn and molasses feed 136; corn, molasses feed and cottonseed meal 122.5;

Feed per Pound Gain.

Adopting the statement found in many books on feeding, viz., that molasses is equal to corn pound for pound, we have the following amounts of grain required per pound gain in the respective groups:

Corn and cottonseed meal 6.36; corn, molasses and cottonseed meal 6.73;

Corn and molasses fed 7.13; corn, molasses feed and cottonseed meal 7.21.

Except for a slightly less amount of silage in the last group, the amounts of roughage eaten per pound gain are practically the same. There is no question that from the standpoint of economy of gain the use of "molasses feeds" are not justified, unless they can be purchased at a lower price than corn.While the number of trials involving both molasses feeds and cottonseed meal is too small to make an average of these trials very reliable, the figures indicate that the addition of the nitrogenous concentrate noticeably

improved the ration. This is to be expected, since the ordinary molasses feeds are not high in protein.

The table also shows that the statement made above regarding the comparative value of corn and molasses is approximately true, viz., that molasses when fed in limited amounts is equal to corn pound for pound. In none of the five lots averaged did the molasses fed exceed five pounds per day. On an average it formed about 30 per cent of the total concentrate ration.

Digestive Nutrients.

In few cases could data be obtained on the digestible nutrients in the various molasses feeds. Being special brands of patented mixtures, it is, of course, impossible to find even their approximate composition in published feeding standards. Discussion under this heading is, therefore, impossible.

Pork Produced Behind Cattle.

In only two cases were data available on the amounts of pork produced behind cattle receiving molasses. The results of these two lots differed widely; so that their average, (1.35 pounds per bushel) cannot be considered as trustworthy. Evidently the use of molasses feed had little effect on the gains made by the hogs kept in the feed lots.

Replacement Value of Feeds.

Because of the small number of cattle fed both cottonseed meal and molasses feed, replacement values for these materials based upon the results given would hardly be reliable. Consequently, they are omitted from the following table.

Table VIIa. Replacement Value of Molasses and Molasses Feeds

	Corn CSM Mixed hay Silage	Corn Molasses Mixed or legume hay Silage CSM	Corn Molasses feed Legume hay Silage
Molasses	+ .4 T Silage + .27 T Hay + 30 bushels corn - .08 T CSM		+1.1 T Silage +1.5 T Molasses feed +20 bushels corn - .85 T CSM - .20 T Hay
Molasses Feed	+ .3 T Hay + .5 T CSM + 7 bushels corn - .5 T Silage	+.65 T Molasses +.55 T CSM -.12 T Hay -.72 T Silage - 13 bushels corn	

VIII. MISCELLANEOUS RATIONS

In the following table are reported three rations that could not well be included in any of the foregoing tables. It is not intended that they be compared with each other, but that each be compared with one or more rations already given and discussed in another connection. The following comparisons might well be made:

(Corn, soy bean meal, oats straw and silage
a (with
(Corn, cottonseed meal, oats straw and silage (Table V, column 6)

(Corn, clover hay, corn and soy bean silage
b (with
(Corn, clover hay, corn silage (Table III, column 1)

(Corn, wheat bran, mixed hay, corn stover
c (with
(Corn, cottonseed meal, mixed hay, corn stover (Table VI, column 2)

These comparisons will not be made in this paper, because of the space such discussion would require. The only reason for including these rations is that they are often used by corn belt cattle feeders, and consequently, have a right to at least a mention somewhere in the discussion.

Table VIII. Miscellaneous Rations

	1 Corn Soy bean meal Oats straw Silage	2 Corn Clover hay Corn and soy bean silage	3 Corn Wheat bran Mixed hay Corn stover
Number of stations	1	1	1
Number of seasons	3	3	6
Number of lots	3	3	12
Number of cattle	30	30	88
Average time fed	168	133	114
Average daily gains	2.33	2.14	1.98±.20
Feed per pound gain			
Corn	5.78	6.19	6.74
Nitrogenous concentrate	1.26		1.07
Hay or straw	.47	2.04	3.91
Silage	10.20	15.40	
Stover			1.44
Lbs. dig. crude protein per pound gain*	.94		.80
Total dig. nutrients per pound gain*	8.05		8.88
Lbs. dig. true protein per pound gain[1]			.74
Total net energy per pound gain[1]			8.22
Average corn per day	13.42	13.20	12.80 Corn 1.91 Bran
Pork per bushel of corn fed cattle	1.80	1.46	

* No data available for corn and soy bean silage.

[1] No data available for soy bean meal.

III. APPENDIX

In all of the comparisons made in the body of this paper no regard was given to the manner in which the corn was prepared. Cattle receiving shelled corn were included with cattle getting ear or ground corn in computing averages. Care was, of course, taken to reduce ear corn and corn and cob meal to a shelled basis, and only lots receiving shelled corn were considered in computing the amount of pork produced per bushel of corn fed. Some three or four rather extensive experiments have been conducted comparing the different forms of corn and they have invariably shown that the form in which corn is fed has much more effect upon the gains made by the hogs following the cattle than upon the gains made by the cattle themselves. The following tables have been prepared showing the average results obtained from feeding corn in the various forms.

Table A. Effect of Preparation of Corn on Daily Gains

	Two year olds			Yearlings			Calves		
	Lots	Total Cattle	Aver. daily gains	Lots	Total Cattle	Aver. daily gains	Lots	Total cattle	Aver. daily gains
Shelled corn	168	1490	2.36	9	90	2.29	34	481	2.02
Ear corn	30	298	2.12						
Corn and cob meal	14	103	2.28						
Corn meal	22	186	2.61				9	88	1.96

Table B. Effect of Preparation of Corn on Pork Production

	Two year olds		Yearlings		Calves	
	Lots	Pork per bu.	Lots	Pork per bu.	Lots	Pork per bu.
Shelled corn	131	1.58	7	.98	14	.88
Ear corn	20	1.48				
Corn and cob meal	6	.75				
Corn meal	7	.45				

While in but few instances have the figures for the amount of digestibl nutrients consumed per pound gain been of much value in interpreting results, they have brought out in a general way the fact that there is a rather close relation between the digestibility of a ration and the rapidity and economy of gains made thereon. The following table gives the figures for the digestible nutrients of all the rations compared.

Table C. Digestible Nutrients Consumed per Pound Gain *

	Time fed	Lots	Cattle	Dig. crude protein	Total dig. nutrients	Dig. true protein	Total [1] net energy
Corn, timothy	110	12	56	.97	11.67	.85	11.32
Corn, prairie	136	3	30	1.09	12.56		
Corn, clover	167	6	68	1.03	10.12	.86	9.65
Corn, alfalfa	138	20	226	1.02	8.37	.80	8.75
Corn, CSM, clover	160	11	115	1.29	9.47	1.17	9.06
Corn, CSM, alfalfa	139	10	97	1.26	8.53	1.06	8.03
Corn, LSOM, clover	103	3	39	1.06	8.12	.91	7.70
Corn, LSOM, alfalfa	128	3	27	1.00	7.00	.82	6.50
Corn, clover, silage	141	7	65	.83	9.42	.75	9.17
Corn, CSM, clover, silage	151	23	215	1.07	8.56	1.02	8.31
Corn, alfalfa, silage	133	10	92	.78	7.97	.68	7.54
Corn, CSM, alfalfa, silage	136	19	142	1.00	8.02	.95	8.01
Corn, LSOM, alfalfa, silage	140	13	92	.84	7.40	.77	7.33
Corn, CSM, silage	150	10	107	.95	8.12	.94	7.50
Corn, CSM, mixed hay, silage	133	7	50	1.01	8.36	1.01	8.27
Corn, CSM, mixed hay, stover, silage	128	7	78	1.00	9.06	.98	8.97
Corn, CSM, oats straw, silage	169	4	39	.94	8.01	.93	7.94
Corn, CSM, mixed hay, stover	133	7	78	.95	8.44	.91	8.13
Corn, molasses, CSM, mixed hay, silage	144	5	38	.95	7.93		
Corn, soy bean meal, oats straw, silage	168	3	30	.94	8.05		
Corn, wheat bran, mixed hay, stover	114	12	88	.80	8.88	.74	8.22
Average	140	195[a]	1772[a]	.99	8.76	.90	8.36

* Based on Table III Appendix, Henry and Morrison: Feeds and Feeding.

[1] Therms

[a] Total

Comparison of different Kinds of Hay When Fed With Corn

	Corn and Timothy hay	Corn and Prairie hay	Corn and Clover Hay	Corn and Alfalfa Hay
Number of stations	2	1	2	3
Number of seasons	5	3	6	10
Number of lots fed	12	3	6	20
Number of cattle	56	30	68	226
Average length of period	110 days	136 days	167 days	138 days
Average daily gain	1.85 .17	1.51	2.08 .14	2.40 .20

The time required for cattle to increase 300 pounds in weight on these rations would be, alfalfa, 125 days, clover, 144 days, timothy, 162 days, and prairie, 200 days.

Comparison of Corn and Legume Hay With and Without Nitrogenous Supplements

	Corn and Clover Hay	Corn C.S.M. Clover Hay	Corn L.S.O.M. Clover Hay	Corn Alfalfa	Corn C.S.M. Alfalfa	Corn L.S.O.M. Alfalfa
No. of stations	2	1	2	3	3	3
No. of seasons	6	10	2	10	6	3
No. of lots	6	11	3	20	10	3
No. of cattle	68	115	39	226	97	27
Ave. time fed	167	160	103	138	139	128
Ave. daily gain	2.08 .14	2.40 .11	3.12	2.40 .20	2.53 .23	3.10

Time required to realize 300 pounds increase in weight:

Clover 144 days; cottonseed meal and clover 125 days; linseed oil meal and clover 96 days.

Alfalfa 125 days; cottonseed meal and alfalfa 119 days; linseed oil meal and alfalfa 97 days.

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